Grade 6
Science
Unit 4: Forces and Motion

Time Frame: Approximately four weeks

Unit Description

This unit is designed to introduce students to the concepts of force and motion with an emphasis on Newton's Laws of Motion. This unit provides a good opportunity to introduce controlled experimentation, as well as the concept of measurement errors and how to address them in data interpretation.

Student Understandings

Newton's Laws of Motion explain movement, direction, speed, and forces that can and do influence objects in nature and in the laboratory. Using models and investigations, the laws of motion can be demonstrated. Students can then explain and predict actions and reactions.

Guiding Questions

1. Can students state and explain Newton's three fundamental Laws of Motion?
2. Can students identify the forces that act upon objects and the effect those forces have on the object?
3. Can students relate their understanding of Newton's laws to real life situations?

Unit 4 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
Note: The following Science as Inquiry GLEs are embedded in the suggested activities for this unit. Other activities incorporated by teachers may result in additional SI GLEs being addressed during instruction.	
1.	Generate testable questions about objects, organisms, and events that can be answered through scientific investigation (SI-M-A1)
2.	Identify problems, factors, and questions that must be considered in a scientific investigation (SI-M-A1)
3.	Use a variety of sources to answer questions (SI-M-A1)
4.	Design, predict outcomes, and conduct experiments to answer guiding questions (SI- M-A2)
5.	Identify independent variables, dependent variables, and variables that should be controlled in designing an experiment (SI-M-A2)

GLE #	GLE Text and Benchmarks
6.	Select and use appropriate equipment, technology, tools, and metric system units of measurement to make observations (SI-M-A3)
7.	Record observations using methods that complement investigations (e.g., journals, tables, charts) (SI-M-A3)
8.	Use consistency and precision in data collection, analysis, and reporting (SI-M-A3)
9.	Use computers and/or calculators to analyze and interpret quantitative data (SI-M-A3)
10.	Identify the difference between description and explanation (SI-M-A4)
11.	Construct, use, and interpret appropriate graphical representations to collect, record, and report data (e.g., tables, charts, circle graphs, bar and line graphs, diagrams, scatter plots, symbols) (SI-M-A4)
12.	Use data and information gathered to develop an explanation of experimental results (SI-M-A4)
13.	Identify patterns in data to explain natural events (SI-M-A4)
14.	Develop models to illustrate or explain conclusions reached through investigation (SI-M-A5)
15.	Identify and explain the limitations of models used to represent the natural world. (SI-M-A5)
16.	Use evidence to make inferences and predict trends (SI-M-A5)
19.	Communicate ideas in a variety of ways (e.g., symbols, illustrations, graphs, charts, spreadsheets, concept maps, oral and written reports, equations) (SI-M-A7)
21.	Distinguish between observations and inferences. (SI-M-A7)
22.	Use evidence and observations to explain and communicate the results of investigations (SI-M-A7)
23.	Use relevant safety procedures and equipment to conduct scientific investigations (SI-M-A8)
25.	Compare and critique scientific investigations. (SI-M-B1)
28.	Recognize that investigations generally begin with a review of the work of others (SI-M-B2)
31.	Recognize that there is an acceptable range of variation in collected data (SI-M-B3)
32.	Explain the use of statistical methods to confirm the significance of data (e.g. mean, median, mode, range) (SI-M-B3)
33.	Evaluate models, identify problems in design, and make recommendations for improvement (SI-M-B4)
36.	Explain why an experiment must be verified through multiple investigations and yield consistent results before findings are accepted (SI-M-B5)
37.	Critique and analyze their own inquiries and the inquiries of others. (SI-M-B5)
39.	Identify areas in which technology has changed human lives (e.g. transportation, communication, geographic information systems, DNA fingerprinting) (SI-M-B7)

Physical Science	
14.	Construct and analyze graphs that represent one-dimensional motion (i.e., motion in a straight line) and predict the future positions and speed of a moving object (PS-M-B1)
15.	Explain why velocity is expressed in both speed and direction (PS-M-B1)
16.	Compare line graphs of acceleration, constant speed, and deceleration (PS-M-B1)
17.	Describe and demonstrate that friction is a force that acts whenever two surfaces or objects move past one another (PS-M-B2)
19.	Identify forces acting on all objects (PS-M-B3)
20.	Draw and label a diagram to represent forces acting on an object (PS-M-B4)
21.	Determine the magnitude and direction of unbalanced (i.e. net) forces acting on an object (PS-M-B4)
22.	Demonstrate that an object will remain at rest or move at a constant speed and in a straight line if it is not subjected to an unbalanced force (PS-M-B5) (PS-M-B3)
23.	Predict the direction of a force applied to an object and how it will change the speed and direction of the object (PS-M-B5)
24.	Describe and give examples of how all forms of energy may be classified as potential or kinetic energy (PS-M-C1)

Sample Activities

Activity 1: How Do You Know It's Moving? (SI GLEs: 1, 4, 5, 11, 12, 19, 23, 25, 31, 32, 36, 37; PS GLEs: 14, 17, 19)

Materials List: chart paper or chalkboard/whiteboard, markers, stopwatches for each partner team or group, 2-3 meter sticks or tapes for each group, science learning logs, pencils, objects to roll and measure for speed (large and medium cans of vegetables, toy cars and/or trucks, or playground balls, etc.), masking tape, graph paper, safety goggles

PART 1 -- Brainstorm with the class to make a list of all things they can observe as *moving* in the classroom. Use a *graphic organizer* (view literacy strategy descriptions) to record their ideas. An example of a graphic organizer that could be used is as follows: one large sheet of chart paper or an area on the chalkboard with room to make a list titled, *Things we think are moving.* Have students revisit this list when they identify what reference point helped them recognize movement. If they need a larger field to consider, use the school grounds and take a walk to identify things that are moving.

Once a large sampling is taken, ask the students to describe how they knew the items were indeed moving. (*They should ultimately get to the point where they recognize that the position changed and that was evident through comparing the change in position with a reference point.*) The teacher may need to guide them to draw this conclusion.

Pose the question, How is movement measured? Students should offer input that refers to how far the object moved (*distance*) and how quickly it changed position (*time*).

We can identify the speed of an object by looking at the distance traveled and dividing that by the time it took to travel that distance. (Speed = distance / time) Elicit comments from the students regarding where they might have heard those terms used together (e.g., Cars travel down the highway in *miles per hour*.).

PART 2 -- Ask students to identify a unit of measure that they could use to describe the speed of an object in the classroom, reminding them they must use metric based measurements (*meters per second*).

Provide an object for each group to roll and then measure its speed. Provide enough room so each group's paths of travel will not cross. If the objects are small, a table or counter can be used, if the objects are larger, the students will need to use the floor or a hall. It would be beneficial to have each group use the same type of object so data can be compared. With this approach the teacher would also be able to point out any extreme differences in data (outliers) that should be questioned or re-tested.

To have students recognize that mass is a factor in motion, the data from teams using large cans (example: 2lb. cans of tomatoes) can be compared to data from teams using medium cans (example: 15oz. cans of tomatoes) OR the speed of small cars can be compared to that of large trucks.

Have teams establish a path or track for their trials and mark the start and finish lines with masking tape. Recommend they use a measured track that will be easy to reference in their final calculations for speed (1 meter for small cars, 3-5 meters for cans, 5-10 meters for balls, etc). Students should identify safety concerns and consider any problems they may run into during this investigation.

Provide meter tapes or sticks for each team and have them create a chart for data collecting in their science *learning logs* (view literacy strategy descriptions). The data table must be labeled and neatly drawn. Provide stopwatches. Review how to use and read the stopwatch. Make certain students understand the importance of running multiple test trials (5-10) and that the data is collected with consistency so that they may make an informed conclusion. Make certain the students are aware that the method of release is a variable that they must consider and that there must be a consistent method of release of the object for each trial. Can students identify the dependent (*responding*) and independent (*manipulated*) variables for this investigation?

The teacher should move about the room and check the student systems as they work.

- Have they set up a reasonable data chart?
- Are they consistent in their rolling of the object and in collecting their data?
- Are they reading and recording the time on the stopwatch correctly?
- Can they set up their data using a graph?

- Have students order their times, and then find an average, mean and median of their recorded times. Can they explain the significance of this information?
- Can they improve on their investigation in any way?

As a wrap up to the investigation, students should compare their graphs and discuss any major differences and what variables would account for those differences. They should recognize that there is an acceptable range for data.

- Can the students identify the variables that affected the way their object rolled? (*surface of the area they used, rug vs., floor, release method, etc*.)
- Lead the discussion to have students consider the way the objects acted as they rolled. Was their speed constant? (*faster at the start, slower until it stopped*)
- What forces acted upon the objects and affected the speed? (*gravity and friction*)
- Can they explain the effect these forces will have on the rolled objects?

Activity 2: Where Does Velocity Come In? (SI GLEs: <u>11</u>, 12, <u>19</u>, 22; PS GLEs: <u>14</u>, <u>15</u>, <u>16</u>, 17, 19)

Material List: weather information from the newspaper (copies for each group), Motion Graphs (labeled) BLM, Motion Graphs (unlabeled) BLM to compare and analyze (copies for each student), hurricane tracking maps, hurricane data from website (for each group)

Graphing the speed and velocity of a storm and reading graphs that show changes in speed are the focus of this activity. Revisit the definition of motion (*a change in position*). Hand each group a copy of the weather page from the newspaper and ask them to identify what feature described on the newspaper page (*winds, cold or warm fronts, tropical storms*) would be considered moving. Have the students scrutinize the information on the pages to identify what new piece of information is added to speed to make weather information more relevant to each population (*direction of movement*). Pose a question to the students, "How does knowing the speed and direction of a weather event help you prepare for that event?"

Have students identify other times when both the speed and direction of an object would be important. (Examples: when traveling on a train, plane, boat, or in a car, when preparing for school, and when you want to go fishing or hunting and you need to know from what direction the winds are coming, etc.) *Speed in a given direction is called velocity.*

Remind students of what forces cause motion to change (friction and gravity). Point out that even moving weather events are affected by forces that cause them to slow down or speed up. Can students identify what force(s) may slow down a tropical storm or hurricane?

Speed can be constant, but most animals and objects do not travel at a constant speed the entire time of the event. Both animals and objects speed up or accelerate and slow down or decelerate (also known as negative acceleration).

Provide a hurricane mapping chart and tracking data for each group to record or graph the various paths of a past hurricane. In doing so, students should note its velocity (speed in a certain direction). See Resource section for websites to obtain this information. If speeds noticeably decrease as the storm gets near land (remember to have students look at distance traveled and the time it took), ask students to identify what force may affect the motion of the storm. (*When the storm hits the land mass, friction comes into play*. If temperature differences exist, there may be a density of air masses to consider.)

Provide students with copies of the Motion Graphs (labeled) BLM which shows acceleration, deceleration, constant speed, and standing still. Use these graphs to discuss how changes in speed or direction are reflected on each graph. Use the unlabeled version to assess student understandings of this concept as a pretest or posttest. Have students identify the different segments on each graph and what they mean for the motion of the object. They should be able to name each graph by the motion it represents.

Activity 3: You Need To Speak the Language (SI GLE: 3, 19; PS GLE: 15, 17, 19)

Materials List: index cards for vocabulary word cards, textbooks, notes, and other available resources to locate definitions of motion terminology

Review or re-teach the meanings of the terms used in this unit: acceleration, forces, friction, gravity, velocity, motion, and speed. To complete *vocabulary cards* (view literacy strategy descriptions) individually and compare finished cards with group members would serve this purpose well. Students will research each vocabulary word, construct a meaningful definition, provide a relevant, real-world example of each, a formula, if available, and illustrate the example. Emphasis should be placed on the student's ability to connect an understanding of these terms with real-life applications they've observed.

Example:

speed in a given direction

Velocity

$$\text{Average Velocity} = \frac{\Delta\,\text{position}}{\text{time}} = \frac{\text{displacement}}{\text{time}}$$

The butterfly's
velocity was ½ mph NNE
as it migrated from Mexico.

Students will select a way in which to share their vocabulary cards. (post them in sets on the wall, create a power point with them, trade until they have a complete set of each, play guessing games using the illustrations and hints, etc.)

Questions or statements to elicit student responses are geared to helping students connect with these terms. These might include the following:

- You observe acceleration in action on your way to school. What form would it take? (*in the auto, changing lanes, going down hill, or passing a vehicle*)
- When would deceleration be helpful or harmful? (*coming to a stop sign, trying to merge onto Interstate*)
- What forces act on you as you go about your daily routines? (*gravity, friction*)
- Explain how the school zone speed limit contributes to the time it might take to travel a particular distance. (*It interrupts your speed and makes it less constant.*)
- What examples at the amusement park would illustrate the terms we have explored? (*lots of examples here, but note, rides that go in a circle have zero velocity because the seat you sit on returns to the same point*)
- How is velocity important to your daily life? (*knowing where to move to get out of the way of a moving vehicle, planning for storms, fishing with the right winds, air traffic controllers directing planes in and out of an airport, etc.*)
- How is *velocity* of an object different from the *speed* of an object?

Activity 4: Inertia—Newton's First Law –--(SI GLEs: 7, 8, 12, 16, 19, 21, 23, 28; PS GLEs: 14, 17, 19, 22, 23)

Materials List: (for each team) a plastic cup, index card, safety goggles, coins (2 dimes and a quarter) or metal washers of a size comparable to the coins, 20 ounce water bottle filled with water and sealed, golf ball, ramp about 24 inches long, 8 textbooks of similar thicknesses, masking tape, rulers or meter sticks, science learning logs, Cooperative Groups cards created in Unit 1, Activity 6

Note: The teacher may choose to create a set of lab instructions for each of these investigations. Use the Cooperative Groups cards and set up a supply station. Once students have the instructions and have gotten their supplies, they can run the investigations themselves. Be sure that students consider safety issues before starting.

Introduce Sir Isaac Newton and his studies as a springboard to the rest of the unit activities and as a reminder that investigations begin with a review of the work of others.

Students should create a data table in their science *learning logs* (view literacy strategy descriptions) to record predictions, measurements, and observations for the following 3 investigations.

Have the students set up the first investigation using the cup, index card, and quarter.

- They must first record a fully worded prediction as to the reaction of the coin when the card is flicked as described in the set-up below (e.g., The card and the coin will fly across the top of the cup together.).
- Cover the cup with the index card. Lay the coin on top of the card. Flick the card only (straight across the cup top) and observe the reaction of the coin. Record observations.

- Each member of the group goes through the same process and records their own observation (card moves away and coin drops into cup).

Have the students set up the second investigation using a quarter and a dime.

- Students must record a prediction first as to the reaction of the coins (e.g., The quarter will travel farther across the table when hit by the sliding dime than the dime will travel when hit by the sliding quarter.).
- Have students place the coins on a smooth, flat surface about 2-3 inches apart.
- Have the students mark the starting point for the target coin (the coin farthest from the student) with a small piece of tape nearby and flick the closest coin at the target. Have them then measure the distance the target travels and the distance the coin they flicked travels, attending to measurements with precision and accuracy.
- Ask students, What do you think will happen if you flick a dime at a quarter? a dime at a dime? a quarter at a dime?
- Have students run multiple tests each using the same strength and the same delivery.
- Record all observations; include measurements in a graph that shows how far each coin traveled when hit.

Have students set up the third investigation using a ramp, a filled, sealed water bottle, a golf ball, and 8 books.

- Have students begin with a prediction as to the reaction of the water bottle and golf ball (e.g., The golf ball will move the bottle full of water 10 cm. away from the starting point).
- Set the ramp up on two books.
- Have students lay the water bottle at the bottom of the ramp.
- They should mark the position of the bottle with a piece of masking tape at the base of the ramp, running in the same direction as the bottle is lying.
- Students will place the bottle on the tape.
- Once the bottle is stationary, have the students place the golf ball at the top of the ramp.
- They will roll the ball, measure the movement of the bottle with the ruler, and record the results. Multiple tests should be run for each ramp position.
- Repeat the investigation, adding two books after each time to increase the height of the ramp.

When all investigations are complete, student groups should report their observations to the entire class, keeping in mind that they are reporting on what occurred based on their evidence and observations. Have students respond to the following questions in their science *learning logs* after all groups have presented. Explain that their answers to these questions become the basis for inferences after their observations are made. Students should be able to clearly distinguish between observations and inferences.

- Why did the coin fall into the cup and not move with the card when the card was flicked? (*force was on the card, not the coin*)
- Why was it important to place the coins on a *smooth, flat surface* when doing the coin investigations? (*friction would be a factor in the response*)

- What caused the coins at rest to move? What impacted the distance each coin moved? (*an object in motion transferred energy*) (*mass of each*) What happened to the coin you flicked towards the other coin once it hit? (*energy from the flicked coin passed to the target coin*)
- How many books did it take to move the bottle the farthest?
- Why do you think the bottle moved even though it was heavier than the golf ball?
- What forces were at work in each investigation? (*gravity, and to a degree, friction*)
- Can you predict a trend from what you observed with the responding movement of the coins? the interactions of the golf ball and bottle?

Activity 5: Newton's Second Law (SI GLEs: 5, 6, 7, 8, 9, 11, 23, 31; PS GLEs: 15, 19, 20, 21, 23)

Material List: (for each group) meter tapes, meter sticks, rulers, safety goggles, stopwatches, triple beam balance scales, film canisters or plastic containers with sand for extra mass, wheeled objects (inexpensive plastic trucks or cars, wheeled vehicles built by students using construction kits, etc.) calculators, ramp large enough to provide a solid starting point for the vehicles, masking tape, science learning logs

Have students revisit safety guidelines prior to beginning the activity. They should consider safe use of the space in the room and the rolling of vehicles.

In this activity, student groups will use a wheeled object to study the relationship between mass and acceleration when a constant force is applied to the object.

Depending on the size of the objects used, measure and mark 1 – 5 meter distances on a flat surface. Be sure to include the ramp in the measurements. Using a ramp standardizes the release method. Students place the vehicle at the top of the ramp, line rear wheels up with a masking tape start line and release, without any push. Make meter sticks, meter tapes, and rulers available for student use during the investigation. They are expected to measure with accuracy at all times.

The object will be released and the time it takes to move the distance will be recorded. Students will need to measure the mass of their objects, and record the time it takes to travel until the object stops (or has negative acceleration). Have students run several trials before adding more mass to their vehicles. Each addition of mass should also be measured and recorded on a student generated chart in their science *learning logs* (view literacy strategy descriptions).

Students should contemplate what problems must be considered in this investigation. Provide access to calculators. The experiment will be repeated by placing additional mass in or on the object. Try using a film canister or plastic container half-filled or filled with sand. Students should see that the increased mass results in a smaller change in speed, thus a smaller acceleration.

The teacher should have the students identify what changes they will see (dependent or responding variable) and what changes they will make (independent or manipulated variables). The trials should be repeated to obtain an average for each variable tested.

Students should note variations in data collected from the different groups, if the groups used similar vehicles. They should discuss if the variations fall within an acceptable range.

In addition to the students completing a laboratory report, summarizing activities should include a class discussion led by teacher-guided questioning and direct instruction as needed, enabling students to respond either orally or in written format to summative questions and tasks as follows:

- Make predictions about the time it will take the vehicle to travel the required distance.
- Use observations and data from the activity to give a definition of accelerated motion.
- Explain the difference between velocity and speed and why velocity is expressed in both speed and direction. Give an example of when knowing both the speed and direction of an object is important.
- Draw and label a diagram to represent the forces acting on the car.
- Predict how the speed and direction will change if the direction of the force changes.
- How does a change in the vehicle's mass affect the acceleration of the vehicle?
- When would students observe that with increased mass, increased force is needed to move the mass? (moving a refrigerator vs. a small table, etc.)
- Write a description of what was learned in the experiment.

Activity 6: Catapults (SI GLEs: 2, <u>4</u>, 11, 12, 14, 19, 23, 33; PS GLEs: 19, 20, <u>21</u>, 22, <u>23</u>, 24)

Materials List: provide information and/or research on catapults and trebuchet if students do not have Internet access, safety goggles, heavy corrugated cardboard from boxes, rubber bands, aluminum pie tin for each group, masking tape, scissors, string, paint stirring sticks, binder clips, paper clips, small 2 oz paper cups, index cards, small wood scraps, science learning logs, pencils, rulers, spring scales (optional), any other materials that the teacher thinks may be useful in constructing a catapult, large pompons (craft section of variety store) or ping pong balls, unlined paper on which students will draw a diagram of their catapult design

Begin with student research on catapults and the trebuchet including their origin and the various types. Provide rubber bands and pompons for each student and a pie tin target for each group. Challenge each student to hit the pie tin target with the pompon using the rubber band as the catapult. Students will need to make various adjustments to their system as they work to hit the target. Tell students to move away from the target once successful so as to identify the longest distance at which they will have success.

After the students have had sufficient time to explore this simple catapult, initiate a discussion of motion and energy and what affects the movement of objects, have students design and create more complicated catapults out of everyday objects. They should provide a written plan that details what materials they will use, how they will build the catapult, and what will create the force needed to propel the load.

Safety concerns must also be considered and prominently addressed in the student plan. Students work in teams to compete with the catapults. They must document their trials with anecdotal notes, measurements, and diagrams. Measurement much be approached with consistency in order to provide reliable data.

All data should be recorded in the science *learning logs* (view literacy strategy descriptions). They will demonstrate their understanding of motion and the forces at work by utilizing the final catapult to project pompons or ping pong balls. Students should be able to recognize that the projectile and arm of the catapult will remain at rest until it is subjected to an unbalanced force.

Distance and accuracy can be charted by providing a target. Students will need to identify all variables (independent and dependant), record their trials and the changes that they made as they pursued a successful catapult. Their final model must be diagrammed and should reflect all of the forces working on the model and should be drawn on unlined paper. Can students determine the magnitude and direction of the forces? Can they identify where unbalanced forces are at work?

At the conclusion have students critique the catapult models, identify problems with design and offer recommendations to improve accuracy or distance.

Students should be able to demonstrate the effect that adding the unbalanced force to the catapult has on the projectile. They should also be able to predict how the direction and magnitude of the force applied to projectile by the catapult will affect the distance the projectile travels and the accuracy of the system as a whole. Can they predict how changing the magnitude of the force of the catapult changes the reaction of the pompon or ping pong ball?

This activity also allows the teacher to introduce or emphasize examples of potential and kinetic energy. If available, students should use spring scales to measure the force their catapult provides.

Activity 7: Seat Belts-R-Us (SI GLEs: 1, 2, 4, 6, 7, 8, 10, 11, 12, 13, 15, 19, 22, 23, 39; PS GLEs: 19, 22, 23, 24)

Materials List: modeling clay, small to medium toy car or truck (one for each group), ramp(s), books for ramp supports, meter sticks or tapes, safety goggles, masking tape, pencil or any other speed bump material (depending on the size of the car), science learning logs

Always begin with a review of class safety guidelines and plans to provide for safety concerns.

Students will use a toy car or truck for this investigation. They will assemble a ramp to test what happens to a passenger moving with the car when the car hits an obstacle.

Students should be introduced to Newton's First Law, The Law of Inertia. Students will demonstrate that a moving object has inertia. A ramp can be set-up against two books with a pencil or such taped to the floor just past the end of the ramp to serve as the "speed bump" or obstacle. A meter stick should also be attached to the floor parallel to the path of the car so as to measure the effect the collision of the car with this obstacle has on the passenger.

Students will create a modeling clay figure to sit in their test car. The figure should be balanced in the car and not stuck in too tightly. The students should record their predictions regarding the direction of the forces working on the vehicles and passengers. They will then run multiple trials, recording their observations in their science *learning logs* (view literacy strategy descriptions) on a data chart.

Students will observe the effect that stopping the car has on the passenger. They should collect quantitative data by measuring how far the passenger traveled after the vehicle stopped quickly and/or qualitative data regarding the condition of the passenger after the vehicle stops quickly. This lab provides a good opportunity to have students identify potential and kinetic energy. Measuring should reflect attention to accuracy.

After several test runs with the measurement data collected, have the students describe what occurred and then explain why it occurred. They should be able to demonstrate and explain that an object will remain at rest or move at a constant speed unless acted upon by an outside force. The passengers in the vehicles should provide many examples of this. The students should be able to apply Newton's Law of Inertia to the investigation and possibly other laws, if they can justify them.

Further tasks/questions might include the following:

- Identify all forces acting upon the car and the passenger.
- Predict how the direction and magnitude of the force affects the reaction (speed and direction) of the vehicle's occupant.
- Identify and describe the variables that are involved in designing this investigation. Do they understand the difference between their description of what occurred and their explanation of why it occurred?
- Explain the benefits of using crash test dummies to evaluate the effects of automobile crashes.
- How does testing with crash dummies compare with a scientific investigation? What are some of the limitations?
- When you are riding in a car and the car stops quickly, why do you fling forward?
- Explain the benefits of seatbelts and headrests in automobiles. How has new technology changed human lives?

Activity 8: Newton's Third Law—Action / Reaction Pairs (SI GLEs: 1, 2, 4, 5, 6, 7, 12, 13 16, 21, 22, 23; PS GLEs: 19, 20)

Material List: two skateboards, rolling chairs or wheeled scooters used in physical education classes, meter sticks or tapes, science learning logs

Safety Note: Students should identify safety issues to be considered for this investigation and create guidelines for use of the skateboards or wheeled vehicles.

Newton's Third Law can be demonstrated by using two students of nearly the same mass/weight and two skateboards. A large clear area is needed either in the classroom or in the hallway. Students sit on skateboards facing one another. Ask students to predict what will happen if they push on each other's hands. Have students on skateboards reach towards one another and push off from each other's hands. (Both will move in opposite directions.)

Run several tests, recording observations each time. Use different students to run additional tests but allow each pair to repeat their test at least three times. Discuss predictions versus what actually happened. Solicit input from the students for suggestions on how to continue the investigation (push off while moving towards each other, push off from a stationary wall, pull towards each other, use different sized students, etc.).

Ask students to predict what will happen and why in each example. They should record their predictions in their science *learning logs* (view literacy strategy descriptions). Have students identify problems and factors that must be considered in the investigation. These should be documented in the *learning log*, also. Run multiple investigations. Discuss predictions versus what actually happened. Have students create diagrams of the results for each investigation, being sure to represent all forces acting on the object (s).

Students should be able to identify all of the variables (independent and dependent). It is important to compare what happens when the students are of equal mass and when they differ in mass. Have a class discussion to make these observations clear. Can the students identify the pattern that evolves through each action/reaction involving changes in mass? Students should be able to discriminate between observations and inferences in their written report.

Use the investigations as a basis for direct instruction on Newton's Third Law of Motion. Students should be able to identify all forces acting on the objects for each investigation.

Activity 9: It's The Law! (SI GLEs: 10, 12, 14; PS GLEs: 19)

Material List: student copy of Newton's Laws from textbook or notes; large index cards; markers; large labels on sentence strips or cardstock for Newton's First Law, Newton's Second Law, and Newton's Third Law; It's the Law! BLM for each student

Students are asked to work with their group and create a list of real life scenarios that give examples of Newton's Laws. They need to make certain to describe or illustrate the scenarios and not just explain the connection.

Have students use the It's The Law BLM which contains a *word grid* (view literacy strategy descriptions) to help them think critically about each of Newton's Laws and identify several scenarios for each. Distribute the handout to each student and have them check which law they think pertains to the illustration pictured.

Once they have their group list completed, students must put each scenario on a separate index card, remind the students they may not use any examples from the BLM. They may use magazine pictures depicting scenarios, draw scenarios, or just depict them through descriptive writing. S must be able to identify all forces acting on the objects in their scenarios.

While the groups work on their list and scenario cards, post labels on a table or the board so students may place their cards under which ever law of motion applies to their cards.

Each group will give their completed set of scenario cards to another group and the receiving group will post the cards on the wall or board where the labels for each law are displayed. The group must correctly place each scenario under the appropriate law. The group responsible for creating the card set will check the placement, but may not move any cards to a different law without allowing the group that placed them to justify the placement. Keep one version of each scenario to use for assessment at a later date.

Sample Assessments

General Guidelines

Assessment will be from teacher observation/checklist notes of student participation in unit activities, the extent of successful accomplishment of tasks, and the degree of accuracy of oral and written descriptions/responses. Journal entries provide reflective assessment of class discussions and laboratory experiences. Performance-based assessment should be utilized to evaluate inquiry and laboratory technique skills. All student-generated work, such as drawings, data collection charts, models, etc., may be incorporated into a portfolio assessment system.

General Assessments

- The student will submit plans, observations, and comparisons for evaluation as each unit continues.
- Students will assist in developing any rubrics that will be used, and will be provided the rubric prior to and/or during task directions.
- Students will be able to explain Newton’s Laws of Motion in writing or orally. Have students brainstorm examples of types of motion. Then ask them to decide if the motions are describing Newton’s first, second, or third laws.
- Given an opportunity to see a bicycle, students will describe in essay form how applying the brake to stop a bicycle is an example of a force applied.

Activity-Specific Assessments

- <u>Activity 2</u>: Students will correctly identify each segment of the graphs provided (horizontal line = stopped, downward sloping line = decelerating, upward incline = acceleration, etc.)

- Activity 5: Students will correctly describe how an objects mass affects its motion. Students will identify friction and gravity as two forces that affect movement

- Activity 7: Students will give a reasonable explanation regarding the use of head rests and seatbelts as related to Newton's Laws.

- Activity 9: Students will correctly match real-life scenarios to Newton's Laws.

Resources

- *Newton's Laws of Motion.* Available online at http://www.glenbrook.k12.il.us/gbssci/phys/class/newtlaws/u2l1b.html *This site has an online quiz for students to check their understanding.* http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html

- *Discoveryschool.com – Making Catapults Available online at http://school.discovery.com/lessonplans/programs/motionforces*

- *Friction Investigation –The Magic School Bus Available online at http://content.scholastic.com/browse/article.jsp?id=1648*

- *Individual storm tracking information is available here* http://weather.unisys.com/hurricane/atlantic/2006/ALBERTO/track.dat

- *Hurricane tracking maps are found here* http://www.accuweather.com/hurricane/facts.asp?partner=accuweather&fact=tracking